Changes in Frequency of Extreme Wind Events in Arctic Seas

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LONG-TERM GOALS

The project objectives are (1) documentation of high-wind events in the Arctic over the past 50 years, (2) a synthesis of output from a suite of state-of-the-art climate models to provide projections of 21st-century changes in Arctic sea ice, wind, temperature, cloudiness and ocean variables; (3) a downscaling of the projected climate changes into scenarios of changes of high-wind events over the Arctic Ocean and subpolar seas; (4) application of (2) and (3) to obtain scenarios of change of high-wave events, vessel-icing conditions, and ocean mixing. While (3) and (4) are the primary long-term objectives, (1) and (2) are necessary prerequisite tasks that have been the emphases of the Year 1 effort.

APPROACH

The research approach has two main components. The first is a data analysis of storm (wind) events and sea ice coverage of the past several decades. This retrospective analysis is based on Arctic coastal/island station data, reanalysis output from the National Centers for Atmospheric Prediction, and satellite passive microwave data. The second component is a synthesis of output from five global climate models, for which the archived output includes control runs (present-day) and greenhouse scenario simulations. The five models, which are the same as those being used for the Arctic Climate Impact Assessment, are those of the Canadian Climate Center, the European Cemter/Max-Planck-Hamburg, the Geophysical Fluid Dynamics Center, the Hadley Centre (version 3) and the National Center for Atmospheric Research (CSM). The greenhouse simulations are forced by the "middle-of-the-road" B2 scenario of the Intergovernmental Panel on Climate Change. The required information on sea ice and its changes are evaluated from monthly fields (observed and projected), while the information on storm (wind) and temperature events requires daily or daily summary fields. Four of the five ACIA models have provided archives of daily winds from a B2 scenario simulation extending through 2100; all five models provide monthly wind fields for evaluations of projected changes in the mean winds.

The observational analysis provides (1) a basis for evaluation of recent observed trends, (2) a validation of the models' fidelity to reality in their control simulations, and (3) a benchmark for assessments of projected changes. The combination of historical sea ice information (limited here to the post-1978 satellite passive-microwave era) and wind data from the reanalysis permits the evaluation of storm occurrences over open water. The same information can be obtained for the 21st-

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14. ABSTRACT
The project objectives are (1) documentation of high-wind events in the Arctic over the past 50 years, (2) a synthesis of output from a suite of state-of-the-art climate models to provide projections of 21st-century changes in Arctic sea ice, wind, temperature, cloudiness and ocean variables; (3) a downscaling of the projected climate changes into scenarios of changes of high-wind events over the Arctic Ocean and subpolar seas; (4) application of (2) and (3) to obtain scenarios of change of high-wave events, vessel-icing conditions, and ocean mixing. While (3) and (4) are the primary long-term objectives, (1) and (2) are necessary prerequisite tasks that have been the emphases of the Year 1 effort.

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century climate scenarios by utilizing the sea ice and wind output from the models. A key hypothesis being tested is that changes in the frequency of open-water storm events in the Arctic result primarily from changes in sea ice rather than from systematic changes of cyclone activity (even though the latter may accompany changes of climate and sea ice).

WORK COMPLETED TO DATE

The following tasks have been completed since the project's inception in October 2001:

(1) The frequency and associated trends of high-latitude wind events have been evaluated for a set of approximately 20 Arctic coastal and island stations.

(2) Reanalysis output has been used to obtain storm statistics for the Arctic Ocean over the past 50 years. The relation between storm frequency by the Arctic Oscillation has been evaluated.

(3) Sea ice projections from five global climate models have been synthesized for the 21st century; a journal paper describing the results was submitted by Walsh and Timlin (2002).

(4) A website depicting current Arctic sea ice coverage and departures from normal (on a regional basis) has been constructed and is now available (http://zubov.atmos.uiuc.edu/CT).

RESULTS

The analysis of historical datasets on high-wind events has been performed using daily synoptic data observations from first-order reporting stations in Arctic coastal regions and islands. The initial analysis shows no indication of significant increases of storm intensity in the Arctic over the past 4-5 decades, although the frequencies of cyclones have increased in the eastern Arctic. At some stations, such as Nome, there has been a decrease of storm activity in the annual mean (Figure 1). During the winter half of the year (October-March), the primary control on cyclone activity in the central Arctic has been found to be the Arctic Oscillation. Results based on NCEP reanalysis output show that cyclone activity over the Arctic Ocean is far more common during the positive phase of the Arctic Oscillation. Impacts of the Arctic Oscillation and associated wind-forcing of sea ice are described in the paper by Zhang, Ikeda and Walsh (2002).

The synthesis of the global climate model projections of Arctic sea ice through the 21st century included an enhancement of information content through an adjustment of each model's projection based on a correction for systematic errors. These adjustments were derived from each model's present-day bias relative to the HadISST observationsl dataset. All five models show decreases of ice extent by 2100, ranging from about 12% to 46% (Figure 2). The mean decrease is approximately 30%, although the percentage decrease is larger in summer than in winter. Only one model (the Canadian model) is consistently ice-free during the summer months by the late 21st century. The results are described in more detail by Walsh and Timlin (2002).

Finally, a website depicting the current state of Arctic sea ice has been constructed and made publicly accessible. Figure 3 shows a depiction of recent (14 September 2002) sea ice coverage from this website. Automated updates of this site's sea ice and snow cover are made on a daily basis, and automated updates of solar illumination occur every 20 minutes. The site also shows current departures from normal (i.e., anomalies), as well as recent time series, for the Arctic as a whole and for

approximately ten subregions. The latter are primarily coastal regions in which marine operations are affected by sea ice.

IMPACT/APPLICATIONS

The compilation of model projections of sea ice coverage provides state-of-the-art estimates of future Arctic sea ice coverage for each decade of the 21st century. The 30% decrease of the annual mean (42% in summer, 18% in winter) have profound implications for surface marine operations – military, commercial and tourism-driven) in the Arctic. The absence of a systematic increase of storminess indicated by the observational data of the past five decades adds to the likelihood of increased opportunities for marine operations in the Arctic. However, the model projections of storm activity remain to be assess thoroughly in terms of both the projected changes and the uncertainties in the projections.

TRANSITIONS

A real-time website of sea ice coverage, with contextual information provided through graphical depictions of recent variations, is now publicly available at http://zubov.atmos.uiuc.edu/CT/. The site is receiving approximately 100 accesses per day by the sea ice community and the general public.

RELATED PROJECTS

The P.I. is the lead author of Chapter 5 (The Cryosphere and Hydrologic Variability) of the Arctic Climate Impact Assessment (ACIA). As such, Walsh is preparing a description of the underlying processes and likely impacts of recent and projected changes of sea ice and snow cover in the Arctic. Some results of the present ONR project are being incorporated into the sea ice section of ACIA Chapter 5. The sea ice section is complemented by other sections (ice sheets and glaciers, permafrost, river and lake ice, hydrologic fluxes) being prepared by contributing authors. A draft of the ACIA report is scheduled for scientific review in mid-2003; publication of the final ACIA report is scheduled for mid-2004.

PUBLICATIONS

Walsh, J. E., and M. S. Timlin, 2002: Northern hemisphere sea ice projections by global climate models. *Polar Research*, submitted July 2002.

Zhang, X., M. Ikeda and J. E. Walsh, 2002: Arctic sea ice and freshwater changes driven by the atmospheric leading mode in a coupled sea-ice/ocean model. *J. Climate*, submitted July 2002.

Zhang, X., J. E. Walsh and M. Ikeda, 2002: What role does the leading climate mode play in the freshening of the Beaufort Sea? *Geophys. Res. Lett.*, submitted September 2002.

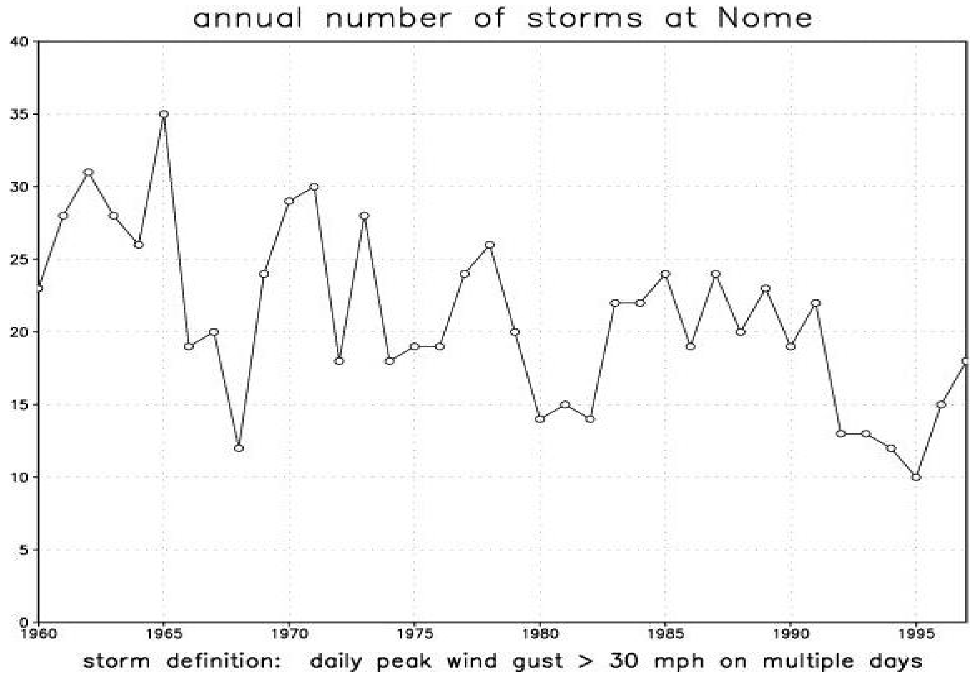

Figure 1. Observed occurrences of high-wind events
[graph: Yearly number of sustained high-wind events (> 30 knots) at Nome, Alaska during the past four decades]

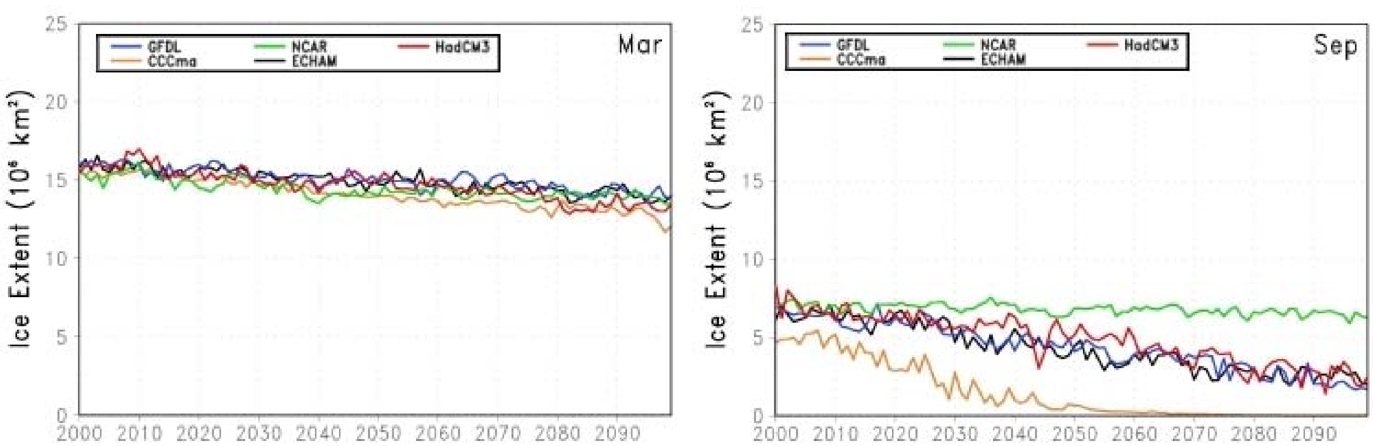

Figure 2. Projections of sea ice coverage
[graph: Time series of 21st-century coverage of sea ice in March (left) and September (right) according to five different global climate models]

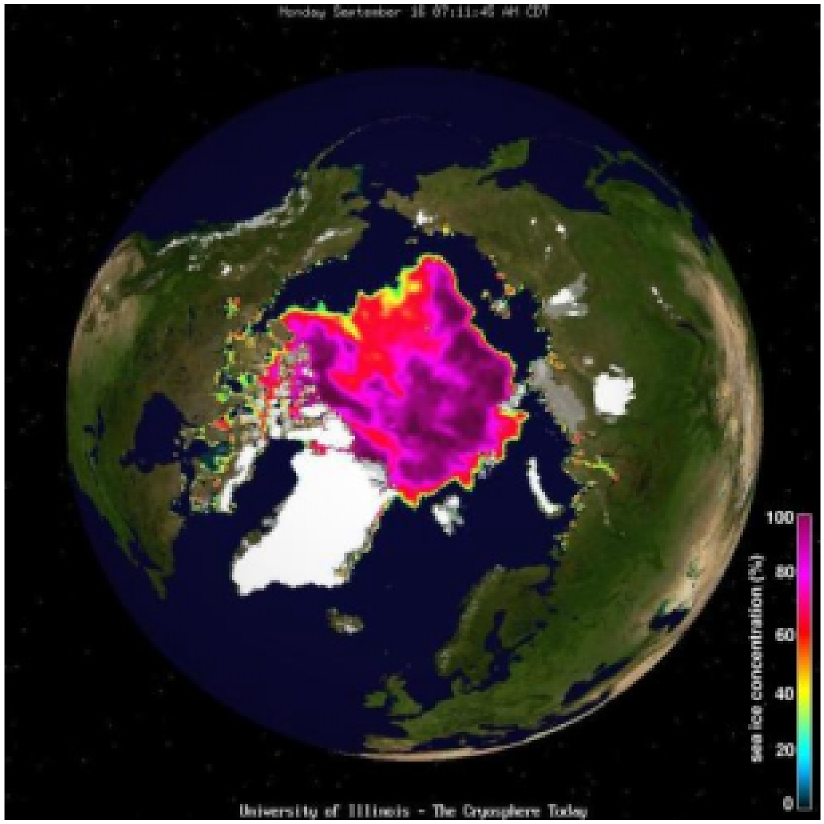

Figure 3. Real-time depiction of the cryosphere
[graph: The coverage of sea ice (color bar gives concentrations) in the Arctic on 14 September 2002]